Foundations of Modern Networking

SDN, NFV, QoE, IoT, and Cloud

By: William Stallings

Chapter 6

SDN Application Plane

Security

Applications in this area have one of two goals:

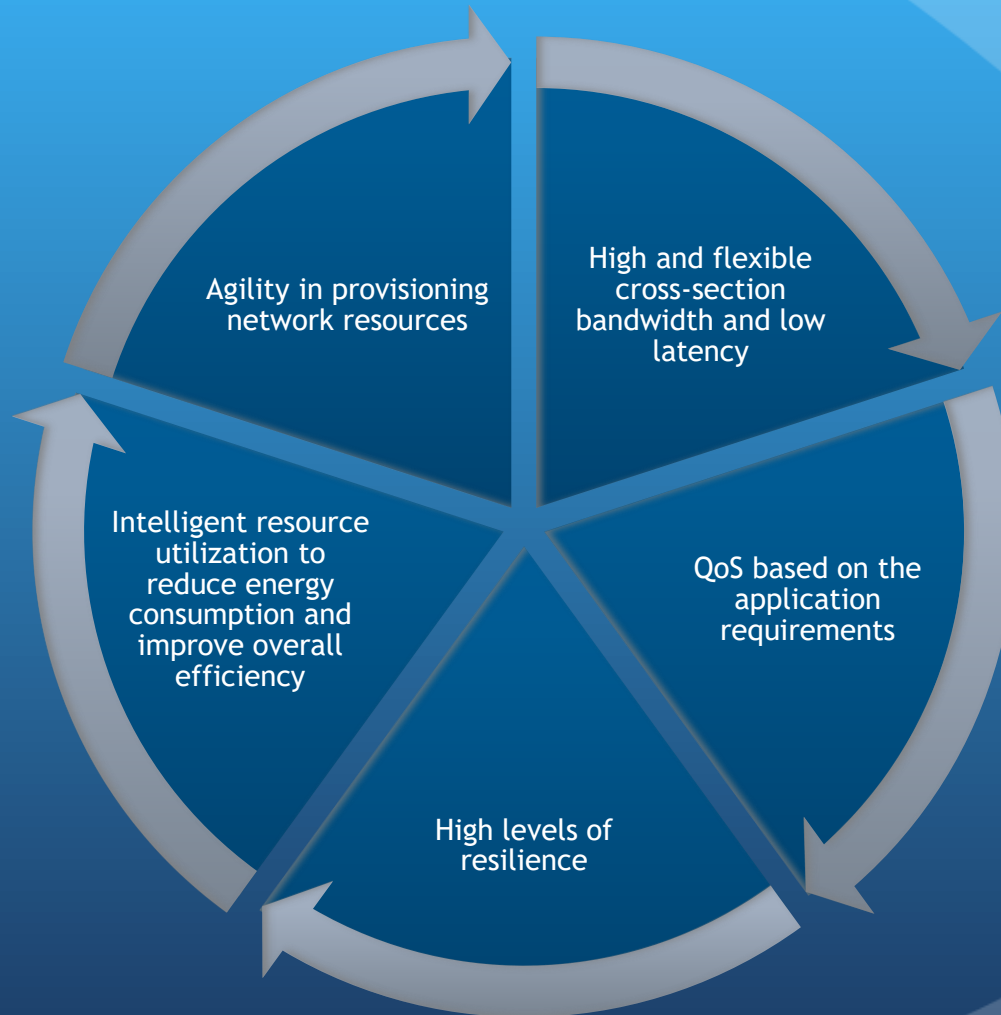## Address security concerns related to the use of SDN

- Threats can occur at any of the three layers or in the communication between layers
- SDN applications are needed to provide for the secure use of SDN itself

Use the functionality of SDN to improve network security

- SDN allows the development of SDN security controllers and SDN security applications that can provision and orchestrate security services and mechanisms

Data Center Networking

- Cloud computing, big data, large enterprise networks, and even smaller enterprise networks, depend strongly on highly scalable and efficient data centers

High and flexible cross-section bandwidth and low latency

QoS based on the application requirements

High levels of resilience

Intelligent resource utilization to reduce energy consumption and improve overall efficiency

Agility in provisioning network resources

Key requirements for data centers

Cloud Networking over SDN

- Cloud Network as a Service (CloudNaaS) is a cloud networking system that exploits OpenFlow SDN capabilities to provide a greater degree of control over cloud network functions by the cloud customer

- CloudNaaS enables users to deploy applications that include a number of network functions

- CloudNaaS primitives are directly implemented within the cloud infrastructure itself using high-speed programmable network elements

Mobility and Wireless

- Wireless networks impose a broad range of new requirements and challenges in addition to all the traditional performance, security, and reliability requirements of wired networks

- Mobile users are continuously generating demands for new services with high quality and efficient content delivery independent of location

- Network providers must deal with problems related to managing the available spectrum, implementing handover mechanisms, performing efficient load balancing, responding to QoS and QoE requirements, and maintaining security

Information-Centric Networking

- Information-centric networking (ICN), also known as content-centric networking, has received significant attention in recent years

- With ICN:
  - A distinction exists between location and identity
  - Instead of specifying a source-destination host pair for communication, a piece of information itself is named
  - After a request is sent, the network is responsible for locating the best source that can provide the desired information
  - The delivery model is shifted from host to user to content to user

- Deploying ICN on traditional networks is challenging because existing routing equipment would need to be updated or replaced with ICN-enabled routing devices

- SDN has the potential to provide the necessary technology for deploying ICN because it provides for programmability of the forwarding elements and a separation of control and data planes

CCNx

Is being developed by the Palo Alto Research Center (PARC) as an open source project

Communication in CCN is via two packet types:

- Interest packets
- Content packets

A CCN has three main data structures:

- Content Store
- Forwarding Information Base (FIB)
- Pending Interest Table (PIT)
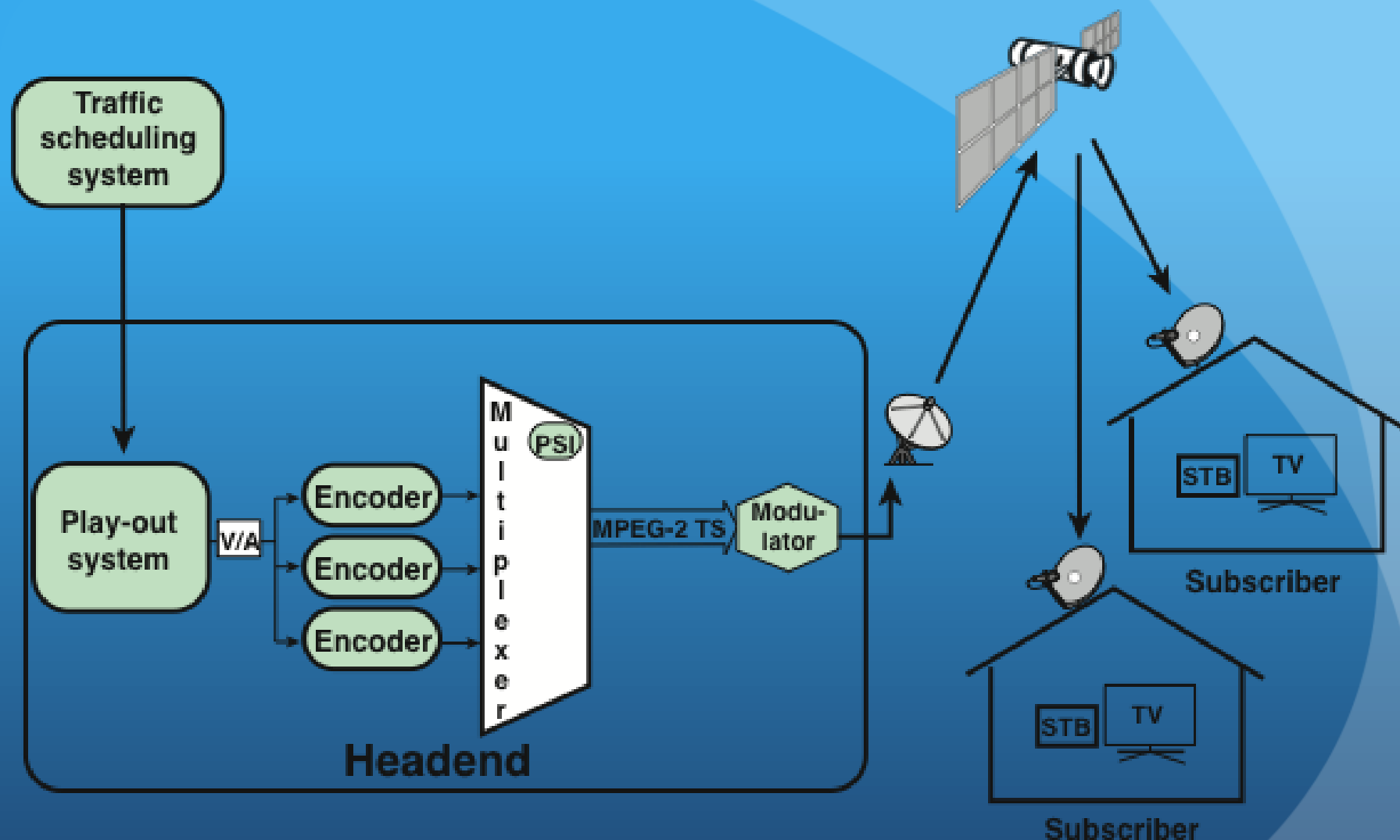
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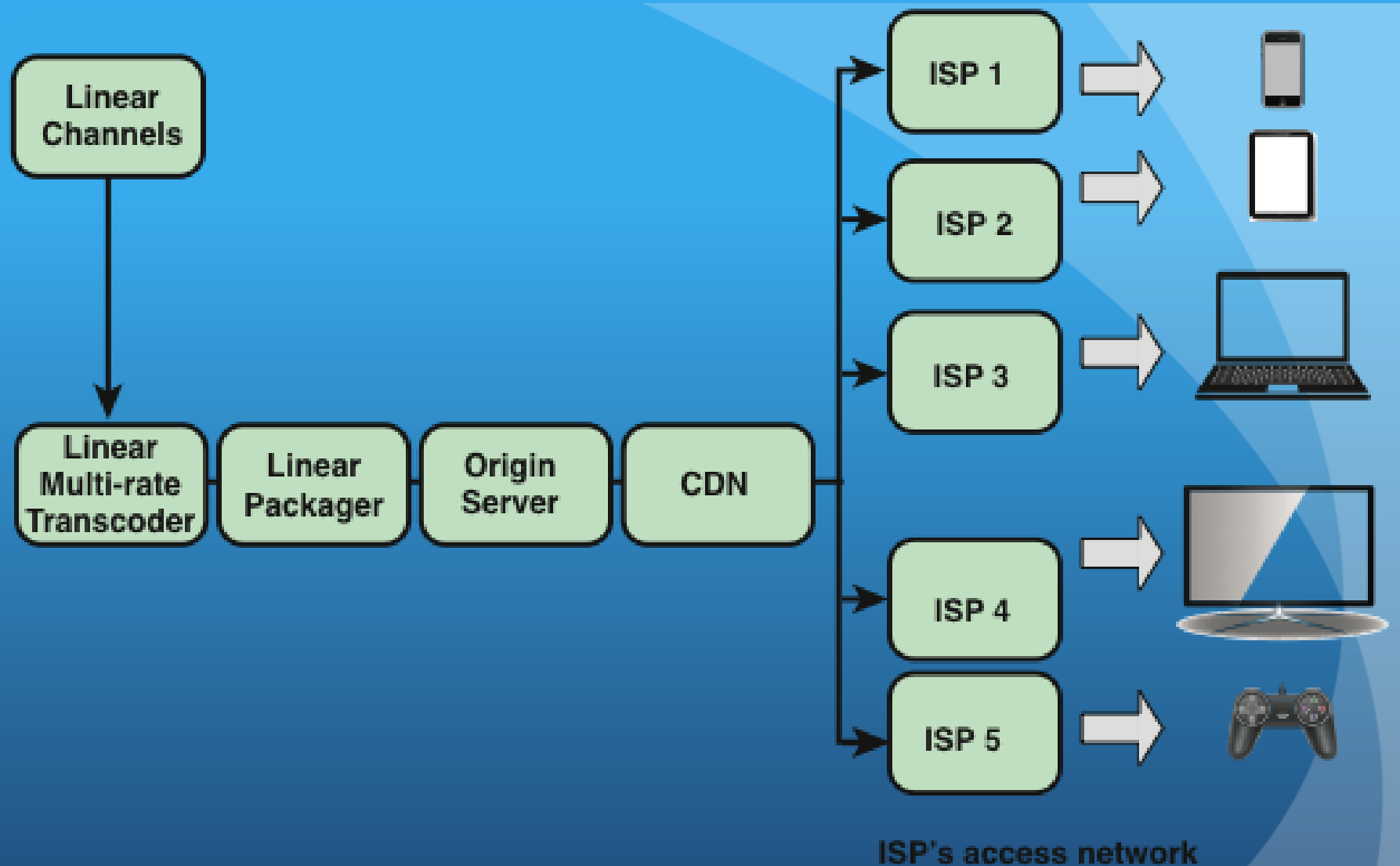
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Chapter 11

QoE: User Quality of Experience

Figure 11.1 An Abstraction of a Content Distribution Network Using a Typical Satellite TV Distribution Network

Figure 11.2 An Abstraction of a Content Distribution Network Using the Public Internet Distribution Network

Service Failures Due to Inadequate QoE Considerations

- The stereoscopic 3D TV service is often cited as a prime example of a service that was a spectacular commercial failure because it had very poor QoE rating

- A number of factors contributed to the failure of these services:
  - The general unavailability of "wow video content"
  - The need to wear special 3D glasses even when using these services in a home environment
  - Because broadcasters were initially in a rush to deploy the 3D TV technology, content was produced by inexperienced creators using inadequate systems and tools

Table 11.1: QoE Initiatives and Projects

Organization	Mission	QoE-related effort
QUALINET	A multidisciplinary consortium for QoE research.	A common terminology for QoE framework
Eureka Celtic	A collaborative industry-driven European research in the area of telecommunications.	Quality of Experience Estimators in Networks (QuEEN) agent to estimate QoE for generic services
International Telecommunication Union— Telecommunication Standardization Sector (ITU-T)	United Nations agency that produces Recommendations with a view to standardizing telecommunications on a worldwide basis.	QoE standardization IPTV QoE Requirements
IEEE Standards Association (IEEE-SA)	A standards-setting body within IEEE, develops consensus standards through an open process that engages industry and brings together a broad stakeholder community.	Standard for Network- Adaptive Quality of Experience (QoE)

Definition of Quality of Experience (QoE)

- QoE requires a multidisciplinary approach, encompassing communication networks, cognitive processes, multimedia signal processing, and social psychology, focused on understanding the user perception of quality

- There is a lack of a consensus of how to measure or describe QoE and the wide range of factors that influence it

- A first step toward a multidisciplinary approach to QoE involves specifying a common terminology framework

- QUALINET
  - European Network on Quality of Experience in Multimedia Systems and Services
  - A group of researchers and industry experts whose main objectives were to foster discussions about the formal definitions of QoE and its related concepts

Definition of Quality

- Quality is the resulting verdict produced by a user after he/she has carried a "comparison and judgment" process on an observable occurrence or event

- This process comprises the following key sequential steps:
    - Perception of the event
    - Reflection on the perception
    - Description of the perception
    - Evaluation and description of the result or outcome

- Quality is evaluated in terms of the degree to which the user's needs have been fulfilled within the context of the event

- The result of this evaluation is usually referred to as the quality score (or rating) if it is presented with reference to a scale

Definition of Experience

- Experience is an individual's description of a stream of perceptions, and his/her interpretation of one or multiple events

- An experience might result from an encounter with a system, service, or an artifact

- It is important to note that the description of an experience need not necessarily result in a judgment of its quality